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## Community structure in soil Acari along a latitudinal transect of Tundra sites in Northern Alaska

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With 2 figures

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### 1. Introduction

Soil microarthropods are an important component of the detritus-based trophic system — the system which processes more than 90% of the net primary production in most terrestrial ecosystems (WHITTAKER 1975; HEAL & MACLEAN 1975). Microarthropods are almost trivial in a direct sense (BUTCHER *et al.* 1971), but by fragmenting litter, cropping microbial populations, and acting as sinks for nutrients (CROSSLEY 1977), they may have a large effect on decomposition rates (WITKAMP & CROSSLEY 1966; see SEASTEDT 1984 for a review). Mites and Collembola constitute the two principal subsets of the microarthropod fauna in tundra (MACLEAN *et al.* 1977). Since the taxonomy of arctic mites is fairly well known (BEHAN 1978), mites were chosen for this investigation of community structure in tundra soils along a latitudinal transect.

Most previous ecological studies on soil mites have related various abiotic factors to total abundance and biomass, and to the distribution limits of particular species (HAARLØV 1960; GILL 1969). Soviet soil ecologists have stressed the zonal concept of animal distribution (CHERNOV 1975; GHILAROV 1967); this is a combination of observations and hypotheses on the geographic distribution of biotical communities. The zonal concept is based on the belief that the distribution and abundance of animals fall into orderly patterns with respect to the zonation of plant communities along latitudinal gradients. The dominant community of a latitudinal zone is considered the zonal type. One criticism of the zonal concept is that the habitat best fitting the hypothesized pattern at any site may be declared the zonal type and the hypothesis becomes self-fulfilling. Proper examination of the zonal concept thus requires investigation of within-site, as well as between-site patterns. KRIVOLUTSKY (1968) was successful in "predicting" oribatid mite abundances in zones ranging from 'arctic' to 'subtropical forest' by means of a simple formula relating a few easily accessible abiotic and biotic parameters. However, his formula was fitted to data in hand and needs to be tested against independent data.

Using the zonal approach as a frame of reference, a number of hypotheses on the organization of soil mite communities in tundra can be formulated. For the mite fauna as a whole, both density and biomass should decrease with increasingly severe conditions (i.e. lower primary production, lower mean temperatures in the active season, shorter growing season, *etc.*). As a corollary to this hypothesis, habitat disturbances should reduce mite density and biomass. Since accumulated soil organic matter tends to higher values in tundra areas of lower productivity (MACLEAN 1974), negative correlations of mite density and biomass with soil organic matter content are expected.

Predictions at the level of higher taxa are limited by our poor knowledge of trophic activities and life histories of soil organisms. The Oribatei, which are primarily microbivores and saprophages (LUXTON 1972; LUXTON & THOMAS 1972; BEHAN & HILL 1978), are gene-

rally relatively large and long-lived mites with low fecundity (MITCHELL 1977). The Mesostigmata are relatively large and are mostly predatory (especially the Gamasina) (WALLWORK 1967); little is known of the reproductive biology of the species encountered in this study. Most Prostigmata are small and apparently short-lived with higher fecundity than the other suborders; they seem to be mostly predatory (WALLWORK 1967). Thus we might expect an increased proportion of the total mite fauna to be composed of Prostigmata as more "severe" conditions are encountered.

At the species level of analysis we expect a number of patterns to emerge. Species richness should decrease with more unfavorable conditions. With increasingly harsh conditions, the mite species should be restricted to more favorable areas within a habitat, resulting in increased spatial heterogeneity of distribution (ANDERSON 1978 b). In general, as species richness decreases in a habitat the more widely distributed or "ubiquitous" species, presumably tolerant of a wider range of conditions, should come to comprise a larger proportion of the fauna.

In this study we address variation in abundance of soil mites and collembolans and in several parameters of community organization in soil mites, with respect to time (sampling date), latitude, and habitat (wet *vs.* dry and undisturbed *vs.* disturbed) along a transect of tundra sites in arctic Alaska.

## 2. Methods

### 2.1. Sites

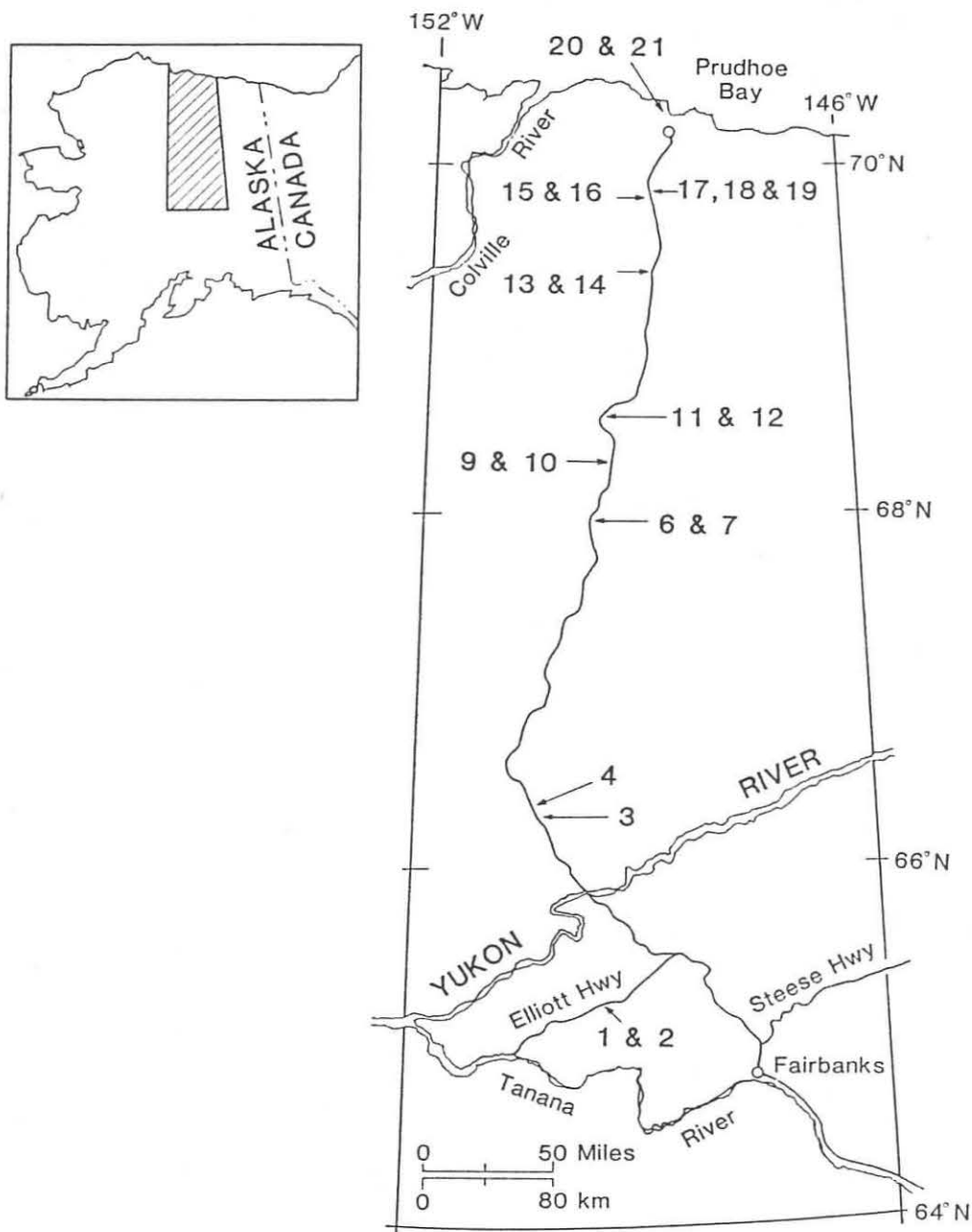
Eight pairs and one set of three study plots, distributed along the trans-Alaska oil pipeline, were used in this study. The 10 m × 10 m plots ranged from 80 km south of the Yukon River to Cape McIntyre on the Arctic Ocean, a distance of approximately 600 km (fig. 1). Seven of the pairs were chosen to represent "wet" and "dry" habitat types at a given latitude. The remaining pair and the triplet of plots were established to compare disturbed and undisturbed plots. The pair was located on the Elliot Highway south of the Yukon River and consisted of a disturbance plot resulting from a fire in 1968 and an unburned control. The triplet was located at the site of an oil spill which occurred on 19 July 1977 as the result of a piece of construction machinery damaging a vent pipe on a pipeline valve, causing a geyser of oil which as it blew downwind in a plume produced a concentration gradient on the ground. Plots were chosen in locations that appeared homogeneous in topography and vegetation, and were representative of the major habitat types in the area. Table 1 gives map coordinates, approximate elevations, and major plant species present in order of importance as ground cover. The transect crosses four geographic provinces: South Slope, Brooks Range, Arctic Foothills, and Coastal Plain. All but sites 1 and 2 are located north of the Yukon River along the trans-Alaska Oil Pipeline Haul Road route. Mileages are measured along the road from the Yukon River crossing.

The south slope of the Brooks Range lies in the continental climatic zone of Alaska, characterized by long, very cold winters and short, relatively warm summers. Elevations range from about 350 m to 1,050 m. This area is forested to the latitudinal timberline south of the Arctic Divide in the Brooks Range, except for islands of tundra vegetation at elevations above about 800 m and in poorly drained permafrost bogs. The mean annual precipitation is 250 mm in the vicinity of the Yukon River and increases near the Brooks Range. Mean maximum temperature in July is above 21 °C with diurnal variation of over 12 °C. Annual thawing degree-days are on the order of 1555. (All weather data from SELKREGG and staff 1975a, b).

The east-west running crest of the Brooks Range divides the southerly flowing streams of the Yukon River drainage from the northerly flowing streams draining to the Arctic Ocean. Latitudinal treeline occurs on the southern side of the range at an elevation of about 800 m. The range is rugged and glaciated, with elevations approaching 2,000 m in the area traversed by this transect. Mean annual precipitation is about 500 mm, decreasing at the northern extent of the range. Both the mean maximum July temperature and the diurnal temperature variation is decreased from the values on the south slope.

The arctic foothills of the Brooks Range are formed by wide east-trending ridges and glacial moraines (in the southern foothills) with elevations ranging from 350 m in the south to 180 m in the north. Mean annual precipitation continues its trend of decreasing with increasing latitude, as do the mean maximum July temperature and the diurnal temperature variation.

The coastal plain is characterized by very limited topographic relief, broken only by occasional pingos (conical hills formed in drained lake basins by a process of frost heaving) and river bluffs. Permafrost lies under a shallow active layer and is involved in the formation of the oriented thaw



1. Location of study plots along a transect across arctic and subarctic Alaska.

lakes, polygonal ground, and pingos. Winters here are severe, with intense cold and high winds. Summers are brief and cool. Annual thawing degree-days by the Arctic Ocean are less than 120 mm at the Arctic Ocean. Mean maximum July temperature is less than 11 °C with a diurnal variation of less than 6.6 °C.

## 2.2. Sampling

Soil samples were taken from the plots to a depth of at least 100 mm (except where prevented by rocks or frozen ground) with a 50 mm diameter corer. In late June and early August of 1977 and 1978 series of ten cores were taken at random from most of the plots. Exceptions were Kanuti Flats (4) and Atigun Dry (10) which were sampled only in June and August of 1978, and the three oil spill plots (17, 18, 19) which were sampled only in June of 1978. Microarthropods were extracted from the cores with a modified high-gradient extractor (*cf.* MACFADYEN 1961). Estimates of organic matter content were obtained from August 1977 cores by determining mass loss on ignition (MACLEAN 1974). Live above-ground vascular plant biomass was measured in August of 1978 by clipping ten 0.05 m<sup>2</sup> quadrats on each of the plots. The material collected was dried at 70 °C for two days and weighed. On the basis of estimates of the parameter *b* of Taylor's power law, a reciprocal square root transformation was used to normalize the data (SOUTHWOOD 1966), and mean dry mass (*m<sub>x</sub>*) per square meter with 95 % confidence limits were calculated for the plots. Table 2 presents mean plant biomass and mean percent organic matter to 100 mm.

Table 1. Locations of study plots and their principal plant ground cover species

Site (Coordinates) (Elevation)	Principal Ground cover species
1. Elliott Highway Burn (65°19'N, 149°06'W) (730 m)	Tussock Heath — <i>Eriophorum vaginatum</i> , <i>Ledum palustre</i> , <i>Rubus chamaemorus</i> , <i>Vaccinium vitis-idaea</i> , <i>V. uliginosum</i>
2. Elliott Highway Control (65°19'N, 149°06'W) (730 m)	Tussock Heath — <i>Eriophorum vaginatum</i> , <i>Ledum palustre</i> , <i>Betula glandulosa</i> (?), <i>Vaccinium uliginosum</i> , <i>V. vitis-idaea</i> , <i>Salix pulchra</i>
3. Finger Mountain (66°15'N, 150°32'W) (840 m)	Lichen Heath — <i>Cetraria</i> sp., <i>Cladonia</i> sp., <i>Dactylina</i> sp., <i>Betula nana</i> , <i>Empetrum nigrum</i> , <i>Ledum palustre</i> , <i>Salix phlebophylla</i>
4. Kanuti Flats (66°17'N, 150°30'W) (400 m)	Mesic Heath — <i>Eriophorum vaginatum</i> , <i>Vaccinium uliginosum</i> , <i>Betula nana</i> , <i>Ledum palustre</i> , <i>Rubus chamaemorus</i> , <i>V. vitis-idaea</i>
6. Chandalar Wet (68°00'N, 149°45'W) (800 m)	Wet Shrub Tundra — <i>Salix</i> sp., <i>Betula nana</i> , <i>Ledum palustre</i> , <i>Carex</i> sp., <i>Eriophorum vaginatum</i> , <i>Vaccinium uliginosum</i> , <i>V. vitis-idaea</i> , <i>Empetrum nigrum</i>
7. Chandalar Dry (68°00'N, 149°45'W) (800 m)	Dry Shrub Tundra — <i>Betula nana</i> (?), <i>Ledum palustre</i> , <i>Salix</i> sp., <i>Vaccinium vitis-idaea</i> , <i>Carex</i> sp., <i>Cladonia</i> sp., <i>Cetraria</i> sp.
9. Atigun Wet (68°16'N, 149°24'W) (900 m)	<i>Carex</i> — <i>Salix</i> Swale — <i>Salix</i> sp., <i>Carex</i> sp., <i>Rhododendron</i> sp., <i>Pedicularis sudetica</i>
10. Atigun Dry II (68°16'N, 149°24'W) (900 m)	Dry Heath — <i>Dryas integrifolia</i> , <i>Salix reticulata</i> , <i>S. arctica</i> , <i>Astragalus</i> sp., <i>Polygonum bistorta</i> , <i>Cetraria cucullata</i> , <i>Carex</i> sp.
11. Toolik Wet (68°38'N, 149°34'W) (800 m)	<i>Salix</i> — <i>Carex</i> Swale — <i>Salix pulchra</i> , <i>Carex</i> sp., <i>Betula nana</i> , <i>Eriophorum vaginatum</i>
12. Toolik Dry (68°38'N, 149°34'W) (850 m)	Tussock Heath — <i>Eriophorum vaginatum</i> , <i>Salix pulchra</i> , <i>Betula nana</i> , <i>Carex</i> sp.
13. Sagwon Dry (69°20'N, 148°40'W) (400 m)	Tussock Tundra — <i>Eriophorum vaginatum</i> , <i>Cassiope tetragona</i> , <i>Salix pulchra</i> , <i>Betula glandulosa</i> , <i>Vaccinium vitis-idaea</i> , <i>Polygonum bistorta</i> , <i>Carex bigelowii</i>
14. Sagwon Wet (69°20'N, 148°40'W) (400 m)	<i>Salix</i> Swale — <i>Salix pulchra</i> , <i>Eriophorum angustifolium</i> , <i>Carex aquatilis</i> , <i>Betula nana</i> , <i>Equisetum</i> sp., <i>Vaccinium uliginosum</i>
15. Franklin Bluffs Dry (69°43'N, 148°41'W) (100 m)	Dry Meadow — <i>Carex bigelowii</i> , <i>Eriophorum angustifolium</i> , <i>Arctostaphylos alpina</i> , <i>Salix pulchra</i> , <i>Cassiope tetragona</i>
16. Franklin Bluffs Wet (69°43'N, 148°41'W) (100 m)	Mesic Meadow — <i>Carex aquatilis</i> , <i>Eriophorum angustifolium</i> , <i>Salix pulchra</i> , <i>Dryas integrifolia</i>
17. Oil Spill, Heavy (69°55'N, 148°52'W) (100 m)	Mesic Meadow — <i>Carex aquatilis</i> , <i>Eriophorum angustifolium</i> , <i>Salix pulchra</i> , <i>Dryas integrifolia</i> , <i>Saxifraga oppositifolia</i>
18. Oil Spill, Light (69°55'N, 148°52'W) (100 m)	(Same as above)
19. Oil Spill, Control (69°55'N, 148°52'W) (100 m)	(Same as above)
25. Cape McIntyre Wet (70°23'N, 148°30'W) (4 m)	Wet Meadow — <i>Carex aquatilis</i> , <i>Eriophorum angustifolium</i> , <i>Salix phlebophylla</i> , <i>S. reticulata</i>
21. Cape McIntyre Dry (70°23'N, 148°30'W) (4 m)	Raised Polygon Center — <i>Carex aquatilis</i> , <i>Eriophorum angustifolium</i> , <i>Salix pulchra</i> , <i>Saxifraga cernua</i>



Table 2. Above-ground vascular plant biomass, and percent organic matter to a depth of 100 mm on each of the study plots

	Live above-ground vascular plant biomass mean $\text{g} \times \text{m}^{-2}$ (95 % Conf. Limits high/low)	Mean % organic matter to 100 mm (variance)
1.	183.9 (293.6/125.9)	87.5 (32.1)
2.	357.6 (517.8/261.7)	71.2 (19.6)
3.	143.2 (198.2/108.3)	55.6 (10.0)
4.	17.1 (670.6/3.7)	92.4 (35.5)
6.	87.9 (197.0/49.0)	26.6 (3.4)
7.	484.2 (820.9/319.1)	52.5 (12.0)
9.	124.3 (271.8/70.9)	40.0 (6.3)
10.	60.9 (90.5/43.8)	23.3 (2.8)
11.	128.3 (226.8/82.4)	72.7 (21.7)
12.	147.5 (199.6/113.4)	64.5 (18.6)
13.	143.9 (184.3/115.5)	59.0 (10.6)
14.	202.1 (276.3/154.2)	34.2 (4.6)
15.	156.1 (186.3/132.7)	3.4 (0.8)
16.	35.0 (51.6/25.3)	7.2 (1.2)
17.	n.a.	n.a.
18.	n.a.	n.a.
19.	n.a.	n.a.
20.	93.6 (120.2/74.9)	54.1 (11.9)
21.	35.5 (87.2/19.2)	64.9 (18.3)

### 2.3. Sorting and identification

After sinking, the samples were sorted to mites, Collembola, and "other" (Protura, Diptera larvae, etc.). Mites of the June 1978 samples, along with those from plot 9 from June 1977 and plot 4 from August 1978, were identified. Adults of Oribatei and Mesostigmata were identified to species. Oribatei juveniles were separated into brachychthoniids and all other; Mesostigmata juveniles were identified to genus where possible, but in a few cases were taken only to subfamily or family. Many of the Prostigmata can be identified to species only with detailed observation of good preparations, often under oil immersion optics. Due to time limitations the Prostigmata were sorted while in alcohol into artificial groups based on size, ranging from species to superfamily, to allow biomass estimation. The Acaridei are not common in tundra soils, and the few that were found were ignored for the purposes of this study. Approximately 12,000 mites were identified from these samples.

### 2.4. Analysis

Counts of mites and Collembola were transformed by  $\log(x + 1)$ , where  $x$  is the count (GERARD & BERTHET 1966; SOUTHWOOD 1966). Transformed means were used in  $t$ -tests as a priori tests of the significance of the differences between two means. LEVENE's joint test of even moments (VAN VALEN 1978), in which the effect of the variance dominates, was used to test the significance of the difference between two variances, since this test is less sensitive to slight departures from normality than is the  $F$ -test.

Variance to mean ratios of greater than unity for mite population density over cores within plots suggested a clumped distribution of the organisms over area. The negative binomial distribution was fitted for the number of individuals per core for each species of Oribatei, including the two categories of juveniles, on each site where the species was represented by two or more individuals. The parameter  $k$  was estimated from this fitted distribution in each case (BLISS & FISHER 1953; BERTHET & GERARD 1965; SOUTHWOOD 1966). Efficiencies of the estimates of  $k$  were estimated from the graph of ANSCOMBE (1950) reproduced in SOUTHWOOD (1966). For each site, log mean population density and  $\log l/k$  were correlated, excluding the few negative and undefined values of  $k$ .

To estimate biomass, DOUCE's (1976b) regressions of dry mass [ $\triangleq$  xeromass  $\triangleq m_x$ ] on products of various body dimensions of the suborders, derived from the Barrow, Alaska fauna, were used for each species, or in the case of the Prostigmata, for each of the artificial categories used. [It should be noted that when DOUCE (1976a, b) used the term gnathosoma, he was, in fact, measuring maximum proterosomal width (*cf.* KRANTZ 1978). Use of the true maximum gnathosomal width in DOUCE's (1976a, b) regression for Oribatei results in biomass estimates that are low by a factor of three to five.] Between 2 (in the case of very rare species) and 20 individuals of each species or category were chosen at random for measurement.

In order to provide an index of constancy, the species were divided into four classes on the basis of the number of plots on which they occur (WALLWORK 1976; BEHAN 1978). "Ubiquitous" species occur on 75 to 100 % of the plots, "common" species on 50 to 75 %, "uncommon" species on 25 to 50 %, and "rare" species on 0 to 25 %.

The average increase in numbers of species of Oribatei and Mesostigmata recorded as increasing numbers of cores were examined was calculated with a computer program which analyzed all possible combinations of 1, 2, 3, . . . , 10 cores in a sample. Differences in the slopes of regression lines of log-log plots of expected numbers of species *versus* number of cores examined between sites were tested with the F-statistic (SOKAL & ROHLF 1969). Another measure of the spatial heterogeneity of the distribution of species within a plot (beta diversity, *sensu* WHITTAKER 1972) was calculated by dividing the total number of species collected from the plot (ten cores) by the mean number of species in one core.

### 3. Results

#### 3.1. Abundance of microarthropods

Tables 3, 4, and 5 present the mean abundance of mites and Collembola at each site and sampling period, along with mite to Collembola ratios. Mite population densities ranged from 4,920 ind.  $\times$  m<sup>-2</sup> at the Toolik wet plot (11) in June 1978 to 164,260 ind.  $\times$  m<sup>-2</sup> at the Chandalar dry plot (7) in August 1978, almost twice the range reported by MACLEAN *et al.* (1977) for various habitats at Barrow. Collembola population densities ranged from a low of 630 ind  $\times$  m<sup>-2</sup> at the Elliott Highway burn site (1) in August 1978 to a high of 37,550 ind.  $\times$  m<sup>-2</sup> at the Chandalar dry site (7) in August 1978, a much narrower and lower range of values than those reported by MACLEAN *et al.* (1977) from Barrow. In examining the data for June 1978 we find no significant correlation between mite population density and latitude (SPEARMAN Rank Correlation  $r_s = -0.38$ ,  $P > 0.05$ ), but population densities at sites north of the Brooks Range are generally lower than those of the southern sites. [The non-parametric test was used because some of the pair-wise comparisons of population densities were heteroscedastic — it is here a conservative test.] Likewise, Collembola show no significant correlation between population density and latitude (SPEARMAN Rank Correlation,  $r_s = 0.22$ ,  $P > 0.05$ ); the trend, however, is the reverse of that seen in mites. Collembola population density is rather high at both Cape McIntyre sites, after being relatively low throughout the foothills and the rest of the coastal plain. Only at the Cape McIntyre plots are Collembola more numerous than mites.

Table 3. The Population density (number  $\cdot$  m<sup>-2</sup>) of soil mites and Collembola to a depth of 50 mm and the mite to Collembola ratio, at each of the study plots in June, 1977

Site		June, 1977		
		Mites	Collembola	Mites
		(ind $\times$ m <sup>-2</sup> ) (0—50 mm)	(ind $\times$ m <sup>-2</sup> ) (0—50 mm)	Coll.
1.	Elliott Highway Burn	16,130	6,500	2.48
2.	Elliott Highway Control	44,020	15,720	2.80
3.	Finger Mountain	40,990	13,620	3.01
4.	Kanuti Flat	n.a.	n.a.	—
6.	Chandalar Wet	68,600	11,230	6.11
7.	Chandalar Dry	77,150	29,480	2.62
9.	Atigun Wet	8,170	1,890	4.32
10.	Atigun Dry	n.a.	n.a.	—
11.	Toolik Wet	5,860	1,820	3.22
a2.	Toolik Dry	10,190	3,870	2.63
13.	Sagwon Dry	19,450	6,910	2.81
14.	Sagwon Wet	16,390	1,780	9.21
15.	Franklin Bluffs Dry	27,450	12,980	2.11
16.	Franklin Bluffs Wet	5,920	2,670	2.22
17.	Oil Heavy	n.a.	n.a.	—
18.	Oil Light	n.a.	n.a.	—
19.	Oil Control	n.a.	n.a.	—
20.	Cape McIntyre Wet	2,470	23,600	0.10
26.	Cape McIntyre Dry	14,870	44,990	0.33

Table 4. The Population density and depth distribution of soil mites and Collembola, and the mite to Collembola ratio, at each of the study plots in June, 1978

		June, 1978							
		Mites (ind · m <sup>-2</sup> )			Collembola (ind · m <sup>-2</sup> )			Mite/Collembola	
Site		(0—50 mm)	(50—100 mm)	% In Top 50 mm	(0—50 mm)	(50—100 mm)	% In Top 50 mm	(0—50 mm)	(50—100 mm)
1.	Elliott Highway Burn	10,500	3,670	74	2,660	1,640	62	3.95	2.24
2.	Elliott Highway Control	26,100	7,970	77	5,600	4,400	56	4.66	1.81
3.	Finger Mountain	25,580	18,550	58	8,450	9,870	46	3.03	1.88
4.	Kanuti Flat	65,650	15,710	81	14,310	5,610	72	4.59	2.80
6.	Chandalar Wet	39,450	7,420	84	3,660	1,230	75	10.80	6.03
7.	Chandalar Dry	15,530	5,320	75	3,600	1,200	75	4.31	4.43
9.	Atigun Wet	23,950	4,290	85	2,260	330	87	10.60	13.00
10.	Atigun Dry	44,020	2,990	94	17,830	8,320	68	2.47	0.36
11.	Toolik Wet	4,290	630	87	770	90	89	5.57	7.00
12.	Toolik Dry	20,690	2,260	90	3,750	830	82	5.52	2.72
13.	Sagwon Dry	34,350	80	99	6,870	360	95	5.00	0.22
14.	Sagwon Wet	18,710	2,790	87	3,620	690	84	5.17	4.04
15.	Franklin Bluffs Dry	15,000	18,760	44	4,920	1,940	72	3.05	9.67
16.	Franklin Bluffs Wet	13,643	2,830	83	6,030	1,730	78	2.26	1.64
17.	Oil Heavy	2,940	5,120	36	1,170	760	61	2.51	6.74
18.	Oil Light	4,680	2,450	66	1,170	690	63	4.00	3.55
19.	Oil Control	12,210	3,710	77	9,170	2,780	77	1.33	1.33
20.	Cape McIntyre Wet	14,100	1,960	88	25,260	1,600	94	0.71	1.23
21.	Cape McIntyre Dry	14,750	820	95	20,640	1,630	93	0.56	0.50

Table 5. The Population density and depth distribution of soil mites and Collembola, and the mite to Collembola ratio, at each of the study plots in August, 1978

		August, 1978							
		Mites (ind · m <sup>-2</sup> )			Collembola (ind · m <sup>-2</sup> )			Mite/Collembola	
Site		(0—50 mm)	(50—100 mm)	% In Top 50 mm	(0—50 mm)	(50—100 mm)	% In Top 50 mm	(0—50 mm)	(50— 100 mm)
1.	Elliott Highway Burn	4,330	1,680	72	550	80	88	7.87	21.00
2.	Elliott Highway Control	55,450	8,620	87	10,170	6,160	62	5.45	1.40
3.	Finger Mountain	24,000	8,700	73	1,740	2,070	46	13.79	4.20
4.	Kanuti Flat	24,740	4,080	86	3,630	730	83	6.82	5.59
6.	Chandalar Wet	15,120	1,950	89	1,720	940	65	8.79	2.07
7.	Chandalar Dry	109,190	55,070	66	22,890	14,660	61	4.77	3.76
9.	Atigun Wet	7,860	1,130	87	610	50	92	12.89	22.60
10.	Atigun Dry	50,790	2,340	96	14,130	1,860	88	3.59	1.26
11.	Toolik Wet	4,570	1,750	72	460	630	42	9.93	2.78
12.	Toolik Dry	46,560	11,240	81	6,390	1,390	82	7.29	8.09
13.	Sagwon Dry	33,250	1,650	95	5,030	870	85	6.61	1.90
14.	Sagwon Wet	8,710	1,420	86	690	150	83	12.62	9.47
15.	Franklin Bluffs Dry	35,890	2,060	95	11,740	1,000	92	3.06	2.06
16.	Franklin Bluffs Wet	12,150	1,500	89	3,030	120	96	4.01	12.05
17.	Oil Heavy	n.a.	n.a.	—	n.a.	n.a.	—	—	—
18.	Oil Light	n.a.	n.a.	—	n.a.	n.a.	—	—	—
19.	Oil Control	n.a.	n.a.	—	n.a.	n.a.	—	—	—
20.	Cape McIntyre Wet	10,320	3,350	76	13,280	520	96	0.78	6.44
21.	Cape McIntyre Dry	34,630	2,510	93	26,890	620	98	1.29	4.05



At four sites mite population density increased significantly from June to August of 1978 (t-test,  $P < 0.05$ ); at five sites population density decreased significantly over the same period. Of the four that increased, three are dry plots and the fourth is the Elliott Highway control plot (2), which is considered to be dry. Of the five that decreased, four are wet plots and the fifth is the Elliott Highway burn plot (1). In comparing *Collembola* population densities in June and August 1978 no such wet-dry pattern is evident. Of the seven plots with significantly different means, six (4 wet and 2 dry) decreased over the season and only one (Chandalar Dry) increased.

Mites were more abundant in dry than in associated wet plots in all significant pairwise comparisons (t-test,  $P < 0.05$ ) north of the arctic divide. This result is consistent with MACLEAN *et al.* (1977) who found a significant negative correlation between soil moisture and mite population density at Barrow. A similar trend is evident for *Collembola*, especially in August 1978; MACLEAN *et al.* (1977) found no relationship between soil moisture and *Collembola* population density. The Elliott Highway control had significantly higher mite and *Collembola* population densities in June 1978, and higher mite population density in August 1978, than did the burned plot (t-test,  $P < 0.05$ ). The remaining comparisons of means between these plots are invalid due to heterogeneous variances. Other interesting comparisons are between the Oil Spill disturbance plots (17, 18) and their control (19). For both mites and *Collembola* there is no significant difference in population densities on the light and heavy oil treatments (t-test,  $P > 0.05$ ), while both of these differ significantly from the control (t-test,  $P < 0.05$ ). Oil, even in relatively low concentrations, reduces microarthropod populations by fifty percent or more.

Seasonal trends in mite abundances and juvenile to adult ratios are apparent. For all site pairs but Sagwon, oribatid juveniles account for a greater proportion of the total oribatid abundance on wet plots than on their dry counterparts in the June 1978 samples. Site 4 at Kanuti Flats was the only site examined in detail for August 1978 and it shows a five-fold decrease in oribatid juveniles from June to August while the adults only show a two-fold decline. The Mesostigmata show a more than four-fold decline while the Prostigmata actually increase from June to August. The Atigun wet site (9) was the only plot examined in detail over two years (June of 1977 and 1978). Adult oribatids increased by a factor of 2.5. The Mesostigmata increased slightly while the Prostigmata increased seven-fold.

### 3.2. Biomass relations

Biomass estimates for individual species are listed in the appendices. Table 6 gives biomass estimates for the total mite fauna on each plot along with confidence intervals extrapolated from abundance data and the mean mass per individual on a plot. Total biomass decreases with increasing latitude. Mean mass per individual on a plot reflects the relative numerical proportions of the three suborders (table 7). Plots with low mean individual masses generally have a large proportion of the relatively small Prostigmata. The Prostigmata significantly increase their proportional contribution to the total acari biomass with increasing latitude (SPEARMAN Rank Correlation,  $r_s = -0.13$ ,  $P < 0.05$ ). Both the Oribatei ( $r_s = -0.13$ ,  $P > 0.05$ ) and the Mesostigmata ( $r_s = -0.24$ ,  $P > 0.05$ ) decline in their proportional contribution to the total biomass with latitude.

### 3.3. Species richness, constancy, and spatial heterogeneity

Within-site species richness is defined here as the total number of species collected on the site from the constant area of ten cores. The appendices give the species of Oribatei and Mesostigmata, the number of cores on each site from which each was collected, and the total number of individuals collected. Richness was determined separately for the Oribatei and Mesostigmata (table 8) since these suborders differ in trophic functions.

Mite species richness is influenced by population density, latitude, and edaphic conditions. Species richness of adult oribatids is very strongly correlated with population density (SPEARMAN Rank Correlation,  $r_s = 0.88$ ,  $P < 0.001$ ) while adult Mesostigmata show a similar, but

Table 6. Mean individual dry mass ( $m_x$ ) and population biomass, with 95% confidence limits, for the June 1978 samples

Site	Biomass to 100 mm depth of soil		95% Confidence limits	
	ind. $^{-1}$ [ $\mu$ g] (From un- transf. data)	Mean $m_x$ $m^{-2}$ (mg)	mg $m_x \times m^{-2}$ Upper	mg $m_x \times m^{-2}$ Lower
1. Elliot Hwy Burn	3.2	45.3	64.4	31.8
2. Elliot Hwy Control	3.6	122.6	186.5	80.4
3. Finger Mountain	1.3	57.4	83.0	39.6
4. Kanuti Flat	1.6	130.2	171.4	98.8
4. Knati Flat (Aug. '78)	1.6	46.1	72.3	29.3
6. Chandalar Wet	2.8	131.0	199.7	86.4
7. Chandalar Dry	1.5	31.3	86.7	11.0
9. Atigun Wet (June. '77)	3.2	26.1	46.6	13.6
9. Atigun Wet	1.2	33.9	54.0	21.2
10. Atigun Dry	2.3	108.1	131.5	88.9
11. Toolik Wet	2.0	9.8	19.0	4.9
12. Toolik Dry	2.5	57.4	105.4	31.0
13. Sagwon Dry	1.8	62.0	128.1	29.7
14. Sagwon Wet	2.4	51.6	77.5	35.4
15. Franklin Bluffs Cry	0.9	30.4	56.6	16.2
16. Franklin Bluffs Wet	2.1	34.6	55.1	21.6
17. Oil Heavy	1.3	10.5	14.9	7.3
18. Oil Light	2.3	16.4	23.8	11.2
19. Oil Control	2.4	38.2	66.5	21.7
20. Cape McIntyre Wet	1.5	24.1	30.8	18.8
21. Cape McIntyre Dry	2.6	40.5	75.7	21.4

weaker correlation ( $r_s = 0.42$ ,  $P > 0.05$ ). Species richness of oribatids decreases with increasing latitude (SPEARMAN Rank Correlation,  $r_s = -0.57$ ,  $P < 0.05$ ); a similar trend in species richness of Mesostigmata with latitude is marginally not significant ( $r_s = -0.52$ ,  $0.10 > P > 0.05$ ). Comparing sites at a given latitude, dry plots have more species of Oribatei than do wet plots except for the two pairs south of the arctic divide. No such pattern is evident with the Mesostigmata. The Elliott Highway control plot (2) has more species of both oribatids (26 *vs.* 16) and Mesostigmata (9 *vs.* 5) than the burn plot (1), and species richness of both Oribatei and Mesostigmata is reduced on the Franklin Bluffs oil spill plots compared with their control. Comparing oribatid richness between geographic provinces we find 43 species on the south slope, 44 in the Brooks Range, 31 in the arctic foothills, and 35 on the coastal plain.

Table 9 presents the percentages of the total oribatid fauna of each site accounted for by the four constancy classes. There are four "ubiquitous" species, five "common" species, 15 "uncommon" species, and 43 "rare" species. These terms are used in preference to ones indicating geographic range because most of the species encountered in this study are known to be widely distributed, and in many cases are circumpolar. Ubiquitous and common species account for a larger proportion of the fauna as richness decreases (SPEARMAN Rank Correlation,  $r_s = -0.55$ ,  $P < 0.05$ ). If all plots except those at the oil spill are included in the analysis, there is no significant relation between latitude and constancy (as measured by the sum of the ubiquitous and common classes) (SPEARMAN Rank Correlation,  $r_s = -0.52$ ,  $P > 0.05$ ). If, however, we exclude the faunistically unique Cape McIntyre dry plot from the analysis, the relationship between constancy and latitude is highly significant ( $r_s = 0.74$ ,  $P < 0.01$ ).

Heterogeneity in the spatial distribution of oribatid species within plots, as indexed by the total number of species collected from the plot ( $N^{10}$ ) divided by the mean number of species per core ( $E[1]$ ) (Table 8), increases with increasing latitude ( $r_s = 0.58$ ,  $P < 0.05$ ). A strong negative correlation exists between species richness and heterogeneity of spatial distribution ( $r_s = -0.85$ ,  $P < 0.01$ ). Also of interest is that heterogeneity and constancy increase in concert ( $r_s = 0.56$ ,  $P < 0.05$ ).

Table 7. Relative contribution of the major groups of soil mites to total abundance and biomass at each of the sample sites in June, 1978

Site	By Abundance			By Biomass		
	Orib. (total) %	Meso. (total) %	Prostig. (total) %	Orib. (total) %	Meso. (total) %	Prostig. (total) %
1. Elliott Highway Burn	53	19	28	57	37	4
2. Elliott Highway Control	69	10	21	69	26	4
3. Finger Mountain	79	5	16	71	24	7
4. Kanuti Flat	78	6	16	69	27	5
5. Kanuti Flat (Aug. '78)	53	3	44	67	17	16
6. Chandalar Wet	78	8	14	81	16	2
7. Chandalar Dry	84	7	9	69	26	6
9. Atigun Wet (June '77)	60	11	29	66	24	10
9. Atigun Wet	36	4	60	39	21	39
10. Atigun Dry	56	8	36	65	24	11
11. Toolik Wet	67	9	24	77	15	8
12. Toolik Dry	32	14	54	26	60	14
13. Sagwon Dry	40	5	56	68	16	16
14. Sagwon Wet	62	20	19	54	41	5
15. Franklin Bluffs Dry	30	3	66	47	14	40
16. Franklin Bluffs Wet	73	3	24	82	10	8
17. Oil Heavy	69	7	24	70	20	10
18. Oil Light	51	3	46	71	18	12
19. Oil Control	57	12	32	67	25	10
20. Cape McIntyre Wet	24	25	51	22	61	17
21. Cape McIntyre Dry	24	10	66	72	18	11

Table 8. Population density and species richness of Oribatei, Mesostigmata and Prostigmata in

		Oribatei					
		Density ind $\times$ m <sup>-2</sup>	% of total density	Species $\times$ core <sup>-1</sup> $\bar{x}$	E [10] E [1]	Total spp.	Juv. Adult
<hr/>							
1.	Elliott Hwy Burn	7,540	53	4.0	4.00	16	0.32
2.	Elliott Hwy Control	27,600	69	8.7	2.99	26	0.53
3.	Finger Mountain	35,240	79	6.0	3.17	19	0.87
4.	Kanuti Flats	61,880	78	9.3	2.58	24	1.61
4.	Kanuti Flats (8/78)	8,740	53	6.0	3.33	20	0.68
6.	Chandalar Wet	37,940	78	9.4	2.66	25	0.57
7.	Chandalar Dry	35,500	84	5.2	3.46	18	0.56
9.	Atigun Wet (6/77)	5,400	60	2.0	4.50	9	1.21
9.	Atigun Wet	10,900	36	2.7	3.70	10	1.96
10.	Atigun Dry	26,280	56	7.4	3.24	24	0.62
11.	Toolik Wet	4,330	67	1.4	6.43	9	2.70
12.	Toolik Dry	8,300	32	3.7	3.51	13	0.70
13.	Sagwon Dry	18,540	40	6.0	3.17	19	0.85
14.	Sagwon Wet	14,110	62	4.7	3.40	16	0.56
15.	Franklin Bluffs Dry	13,850	30	4.9	3.88	19	1.52
16.	Franklin Bluffs Wet	13,750	73	3.6	4.17	15	3.45
17.	Oil Spill, Heavy	5,200	69	2.7	3.70	10	1.04
18.	Oil Spill, Light	3,770	51	2.0	5.00	10	1.85
19.	Oil Spill, Control	11,360	57	3.2	3.75	12	1.37
20.	Cape McIntyre Wet	3,720	24	1.3	5.38	7	2.86
21.	Cape McIntyre Dry	4,640	24	2.5	4.00	10	0.52

Table 9. Relative (%) contribution of species of various distributional characteristics: ubiquitous, common, uncommon, and rare, to the total species richness of Oribatei in each of the study plots

Site <sup>1)</sup>		Ubiquitous [%]	Common [%]	Uncommon [%]	Rare [%]
1.	Elliott Highway Burn	19	19	38	25
2.	Elliott Highway Control	15	12	27	46
3.	Finger Mountain	21	16	21	42
4.	Kanuti Flats	17	17	38	29
4.	Kanuti Flats (Aug. '78)	20	20	25	35
6.	Chandalar Wet	16	16	28	40
7.	Chandalar Dry	22	17	33	28
9.	Atigun Wet (June '77)	33	0	33	33
9.	Atigun Wet	20	10	40	30
10.	Atigun Dry	13	17	29	42
11.	Toolik Wet	22	33	33	11
12.	Toolik Dry	31	23	38	8
13.	Sagwon Dry	21	21	32	26
14.	Sagwon Wet	25	19	19	38
15.	Franklin Bluffs Dry	21	21	26	32
16.	Franklin Bluffs Wet	27	27	33	13
17.	Oil Spill, Heavy	30	10	50	10
18.	Oil Spill, Light	40	10	40	10
19.	Oil Spill, Control	33	17	25	25
20.	Cape McIntyre Wet	43	14	29	14
21.	Cape McIntyre Dry	10	20	40	30

<sup>1)</sup> all data from June 1978 unless otherwise noted.

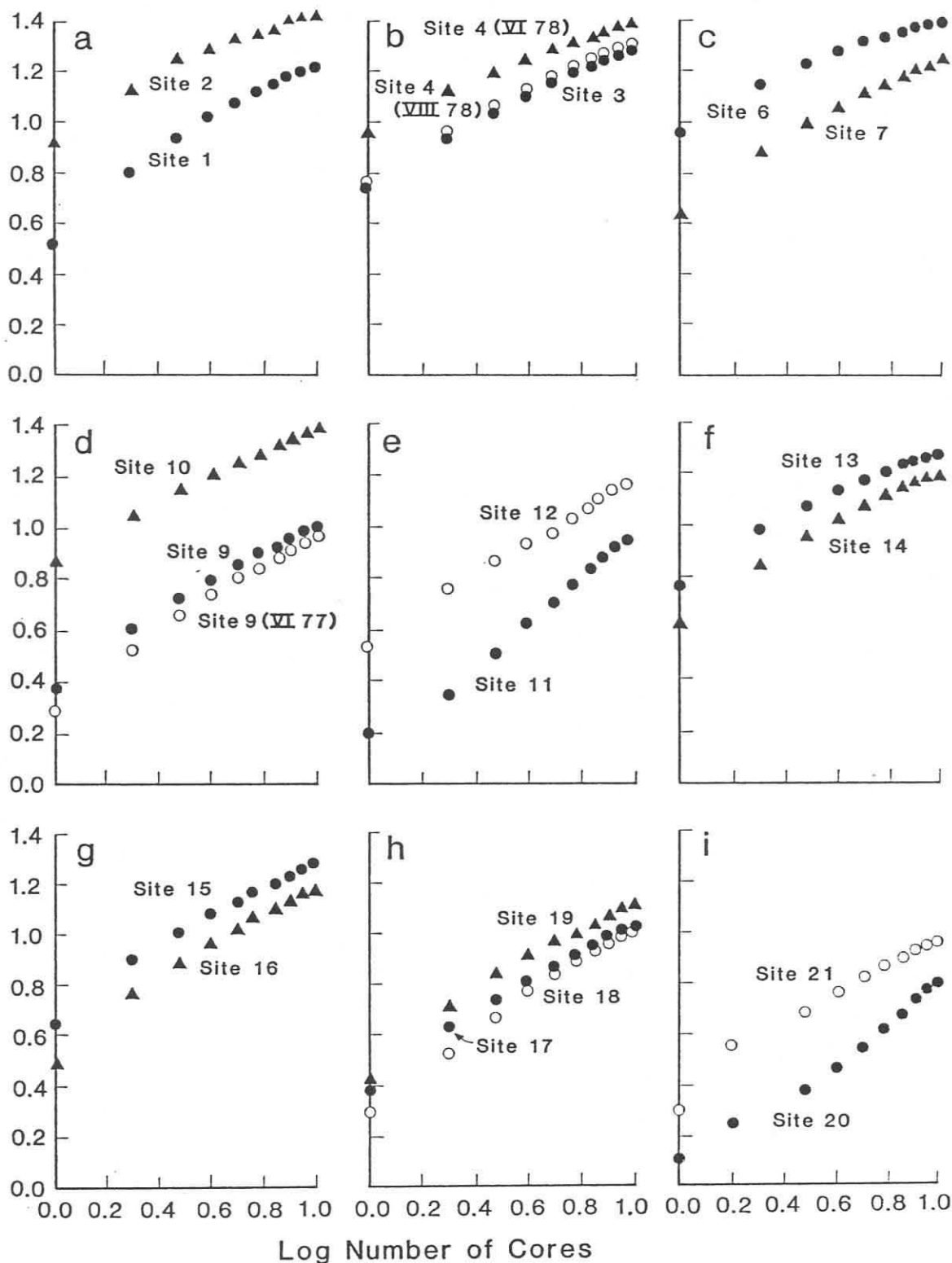
Mesostigmata				Prostigmata	
Density	% of total density	Species $\times$ core <sup>-1</sup> $\bar{x}$	Total spp.	Density	% of total density
2,700	19	1.6	5	4,020	28
4,070	10	1.6	9	8,610	21
2,140	5	1.2	7	7,130	16
4,430	6	2.2	7	12,940	16
968	3	—	4	15,790	44
4,070	8	2.4	6	6,570	14
2,950	7	1.2	6	4,020	9
1,020	11	—	4	2,650	29
1,270	4	0.7	6	18,440	60
3,570	8	1.8	4	16,760	36
560	9	0.6	2	1,580	24
3,670	14	1.9	5	14,260	54
2,190	5	1.0	3	26,180	56
4,480	20	1.7	5	4,230	19
1,430	3	1.1	8	30,150	66
510	3	0.3	3	4,530	24
510	7	0.3	2	1,780	24
260	3	0.4	3	3,360	46
2,340	12	1.3	8	6,320	32
3,920	25	1.3	5	8,000	51
2,040	10	0.5	2	12,940	66

Another way of looking at this heterogeneity of distribution is based upon the relationship of expected number of species versus number of cores examined (area sampled) (fig. 2). These graphs are not, strictly speaking, species-area curves, but represent sampling distributions; however, the straight line on a log-log plot is similar to the familiar species-area relationship. In all cases the more species rich plot of a wet-dry pair has the lower slope, indicating a more homogeneous distribution of species.

The parameter  $k$  of the negative binomial distribution provides us with a means of looking at the structure of the spatial heterogeneity of oribatid species distribution. We might expect that as the population density of a species decreases, its heterogeneity of distribution, or degree of clumping (HAIRSTON 1959), as measured by  $k$  would increase. Though the large majority of the estimates of  $k$  have an efficiency of less than 90 %, there remains an unmistakable trend with population density. Of the 21 site samples examined, 18 have negative correlations of log mean population density with log  $1/k$ , eight of which are significant ( $P < 0.05$ ). None of the three positive correlations are close to being significant ( $P \gg 0.05$ ), though they are all from the three northern-most sites. Thus, low density species have greater heterogeneity of distribution.

Analysis of the within-habitat, between core occurrence of important species provides us with another means of looking at the community structure of oribatids. A high incidence of negative correlation in species pairs should characterize a competitively organized community (Hypothesis I). Where species respond similarly to microsite richness, we might alternatively conclude that productivity or physical suitability provides the basis for community structure. This would be indicated by a high incidence of positive correlations between species (Hypothesis II). Where species respond independently to different environmental factors there is no basis to claim that the community is "organized"; in this cases correlation coefficients should cluster about zero (Hypothesis III). We arbitrarily declared that a species must appear in at least 6 of the 10 cores to be included in the analysis, since an excess of 0-0 cores produces spurious results in a correlation analysis. This made possible 75 pairwise comparisons, obviously biased toward plots with greater abundance. The results show no difference of positive ( $n = 38$ ) and negative ( $n = 37$ ) correlation coefficients, thus





2. Increase in number of species recorded with increasing number of cores examined for each of the study plots. See text for further explanation.

rejecting the predictions of hypotheses I and II. There were, however, 10 cases of  $r = -0.5$  to  $-1.0$ . We considered the possibility that fit to one or another of the models was related to abundance. Pairs of abundant species might be more likely to fit the competitive model (I). We separated our sample of 75, based upon the sum of abundance of the two species, into 40 cases of relatively abundant species pairs and 35 cases of less abundant species pairs. Contrary to this hypothesis, the set of less abundant species showed the greater incidence of negative correlations; however, neither of the two distributions differs significantly from hypothesis III, which predicts equal numbers of positive and negative coefficients. Unfor-

Unfortunately, we could not search for latitudinal patterns because there were too few species north of the Brooks Range with sufficient frequency in any plot to allow calculation of correlation coefficients.

#### 4. Discussion

We would like to be able to say that the abundance of mites and Collembola varies in concert with the rigor of the environment in which they are found. The problem comes with trying to measure "rigor" in terms meaningful, and hence with predictive value, at the level of these organisms. We are confronted with the common situation in ecology where the easily measured variables and the variables of real interest are not the same. Measuring percent organic matter gives us an indication of the amount of potentially available resources for the detritus system and of pore space (presumably physical space rather than food could be limiting to microarthropods in some systems) — but it tells us nothing about decomposition rates or the quality of the resource. A much more relevant measure of the energetic base of soil microarthropod communities would be annual input of detritus. This measure, rather than plant biomass or accumulated organic matter, correlates well with measures of invertebrate abundance and activity (MACLEAN 1981). Unfortunately, it is not easily measured and correlates poorly with plant biomass where communities of radically different growth-forms (e.g. grass-sedge, deciduous shrub, and evergreen shrub) are being compared.

Despite the hindrance of small sample sizes, a relationship of total mite abundance with habitat type over the course of a season is apparent. Mite abundance tends to decrease on wet plots and increase on dry plots. Table 6 gives a hint of the structure of these changes. BLOCK (1966) also reported seasonal trends in both oribatid abundance and juvenile to adult ratios and suggested that peaks in juvenile abundance could be caused by eggs hatching in response to climatic factors. However, as MITCHELL (1977) made clear, unless recruitment patterns are examined, little knowledge of the biology of the oribatids themselves is gained through examination of seasonal fluctuations in population density. In general oribatid juveniles seem to be more susceptible than adults to water stress (BUTCHER *et al.* 1977); this could account, in part, for their larger decline over the season. Generation times for some oribatids in temperate areas have been estimated at a year and less, and are known to increase with decreasing temperature (BLOCK 1965). MITCHELL (1977) determined generation times of three and four years for some oribatid species in an aspen woodland in Canada. Since the temperature regimes in all the plots in the present study are harsher than that encountered by MITCHELL (1977) we can take these as minimum estimates for generation times in arctic tundra areas. Given long generation times and relatively low fecundities, the fairly stable adult population we observe would be expected. It would be instructive to follow over the course of several seasons a number of populations of oribatid species that differ in size (i.e. development time) and diet.

The relative abundance of mites and Collembola follows the pattern established in other studies in the arctic (DOUCE & CROSSLEY 1977; BEHAN 1978); mites are more abundant than Collembola at all study plots but those at Cape McIntyre, which are similar to those found at the area of Barrow, Alaska (DOUCE & CROSSLEY 1977). Almost 10 km inland from the Cape McIntyre site mites were more abundant than Collembola in a dry *Dryas integrifolia* heath but Collembola were more abundant in a mesic *Dryas* — graminiform heath (MACLEAN 1975). If, however, we look at the mite to Collembola ratio for the top 50 mm of the soil for June 1977 and 1978 on all the plots, we find that for all wet-dry pairs except Cape McIntyre in 1977 and Franklin Bluffs in 1978, the wet member has the higher ratio, indicating relatively more mites. BOHNSACK (1968) and MACLEAN *et al.* (1977) found a greater proportion of Collembola in wet habitats at Barrow. Thus, the littoral tundra of the northern coastal plain differs from the inland tundra communities found along the remainder of the transect.

Biomass decreases with increasing latitude, reflecting general decreases in both population density and mean mass per individual. The latter is a reflection of the increasing proportion of the small Prostigmata. The plots at Cape McIntyre yielded total acarine bio-

mass estimates lower by factors of two to four than those reported by DOUCE (1976a, b) for Barrow. However, the dry plot at Cape McIntyre (21) shows a similar proportional distribution of the biomass among the suborders. The wet plot (20) on the other hand is strongly dominated by the Mesostigmata, a situation which only recurs at the Toolik dry plot (12). The lichen heath plot (4) at Finger Mountain yields similar values for both biomass and abundance to those reported by SOLHOY (1975) for a lichen heath at Hardangervidda, Norway.

Although biomass provides better estimates of the biotical activity of mites than does population density (WALLWORK 1967; DOUCE 1976a, b), it remains an imperfect measure. Dry mass is heavily influenced by exoskeleton and hence over-emphasizes the thickly armored oribatids at the expense of the less heavily sclerotized, more agile, Prostigmata. As GHILAROV (1967) has stated: "the total weight [mass] of living organisms belonging to different groups is not comparable", rather it is the "active plasma which determines to activity of an organism". Thus a more meaningful (and much more difficult to obtain) measure of biological importance would be metabolic rate. WOOD & LAWTON (1973) present respiratory rates and mass-specific respiratory rates for a number of oribatid and Mesostigmata species at 10 °C including results for non-gravid and gravid females. MACLEAN (1981) estimates the metabolic activity of mites in the Barrow area using the values of  $0.7 \mu\text{l O}_2 \times \text{consumed mg}^{-1} \text{m}_x \times \text{hr}^{-1}$  for Oribatei,  $1.3 \mu\text{l O}_2 \times \text{consumed mg}^{-1} \text{m}_x \times \text{hr}^{-1}$  for Mesostigmata, and  $1.4 \mu\text{l O}_2 \times \text{consumed mg}^{-1} \text{m}_x \times \text{hr}^{-1}$  for Prostigmata. These values reflect the differences in structure and activity of three suborders.

More information on community structure resides at the species level of analysis, but before discussion of these results it is necessary to acknowledge some of the problems inherent in the approach taken in this study. First of all we are dealing with "morphospecies", i.e., species defined solely on the basis of external morphology. Outside of a few economically important species very little is known of the population structures of mites, particularly of soil forms. Thus the importance of dispersal and genetic variation over area is completely unknown, as are the effects of clonal differences in the very widespread parthenogenetic members of the Nothoidea (GHILAROV 1975), rendering our interpretations of species patterns at the community level more uncertain. There is evidence that many species can be quite variable in their habits under different conditions (ANDERSON 1978a). In the case of some brachychthoniid species, polymorphisms are suspected (R. A. NORTON, personal communication; personal observations). In this study the conservative approach of "lumping" was taken when there was doubt as to the distinction between two forms. Another important problem involves the sampling scheme used in this study and others of its type. As is standard practice, a constant number of cores (10) was taken from each plot at each sample period; thus an equal area was sampled from each plot. The observed correlation between species richness of oribatids and population density may simply reflect the difficulty of detecting uncommon species in low-density populations. A more theoretically troubling problem is the fact that we are not sampling from identical species-abundance functions across the range of sites. This implies that even given equal total abundances and equal numbers of species on two plots our estimates of species richness could be quite disparate given different distributions of individuals among species. SANDERS (1968) in his study of marine benthic invertebrate communities was able to resolve these problems by plotting number of species observed or expected as a function of the number of individuals in the sample (i.e. the curves are derived from a sampling distribution (May 1975)). Unfortunately, his methods are not applicable to populations with aggregated distributions. This problem does not seem to have been dealt with in the literature as yet. Even if this situation becomes statistically tractable, it is likely that the sample sizes necessary would be prohibitive in a study of this scope. Thus we are at present left with the option of continuing with traditional methods but cognizant that our ignorance of much of the basic biology of these organisms limits our interpretations of patterns at the community level.

Despite these reservations, it is clear from this study and from a number of others (BEHAN 1978) that within-habitat richness of oribatids decreases with increasing latitude. Considered

over geographic provinces, however, the total numbers of oribatid species are quite similar. It seems plausible that, as more severe conditions are encountered, animal species are more restricted to favorable microsites. Consistent with this hypothesis, (1) the heterogeneity of spatial distribution of oribatid species increases with increasing latitude and decreasing species richness, and (2) the differences between wet and dry plots of latitudinal pairs increases with increasing latitude.

The distribution of within-site correlation coefficients of abundances of oribatid species pairs is certainly suggestive that the forces of community organization in these habitats are weak. Of course, these data do not disprove competition or microhabitat specialization; they do, however, indicate that the only way the question will be resolved is through experimental manipulations of soil populations, perhaps along the lines of ANDERSON's (1978a) work.

Burning tussock heath vegetation clearly produced long-term perturbations in the detritus system. After a period of ten years, organic matter has apparently accumulated and yet plant biomass (and presumably productivity) remains considerably depressed on the burn plot, despite its visual similarity to the unburned control. Microarthropod population densities, mite species richness, and mite biomass remain significantly depressed. This suggests that even older disturbances should be examined.

Oil plainly caused disruption of soil microarthropod communities and presumably of the whole decomposer system. Even at low concentrations microarthropod population densities are significantly reduced, and at higher concentrations species composition of oribatids is substantially changed. Further work on the effects of oil on soil invertebrates and the entire decomposition process is needed. Properly controlled disturbances could give us some new insights into the operation of the detritus-based trophic system in tundra.

The zonal concept loses its utility in relatively fine resolution work such as the present study. Clear patterns of community organization in soil microarthropods with respect to the zonation of plant communities along latitudinal gradients are not evident in this work. A more profitable approach to the study of soil microarthropod communities would follow in detail a few species with diverse life histories in a variety of habitats along with some well-controlled experimental areas. This approach should give us some idea how the range of population responses interact to hield a community of soil organisms.

## 5. Acknowledgements

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# Appendix 1. Oribatei

Species	South Slope 43 spp.				Brooks Range 44 spp.			
	Site							
	1	2	3	4	6	7	9	10
<b>ORIBATEI</b>								
<b>Brachychthoneidea</b>								
Brachychthoniidae								
<i>Brachychthonius arcticus</i>		1/1						
<i>Brachychthonius jugatus</i>			1/1	1/2				
<i>Brachychthonius</i> sp.		4/11	1/1	4/10			2/3	
<i>Eobrachychthonius</i> sp.		1/1	10/59	10/95	3/7	4/6		
<i>Liochthonius scalaris</i>	1/1	5/15	7/21	8/19	2/6	4/6	9/38	8/39
<i>Liochthonius perpusillus</i>		4/7	1/3	2/2			4/5	4/4
<b>Eulohmannoidea</b>								
Eulohmanniidae								
<i>Eulohmannia ribagai</i>		5/30	2/4					
<b>Perlohmannoidea</b>								
Perlohmannidae								
<i>Perlohmannia</i> nr. <i>coiffaiti</i>	2/2	4/14	2/2		1/1			
<b>Nothroidea</b>								
Nothridae								
<i>Nothrus pratensis</i>					3/5			
Camisiidae								
<i>Camisia horrida</i>			1/1			1/1		1/1
<i>Heminothrus longisetosus</i>			1/1	1/1				
<i>Playthnothrus punctatus</i>				2/2	1/1		1/2	
<b>Belboidea</b>								
Damaeidae								
<i>Epidamaeus arcticola</i>		1/1						4/7
<i>Epidamaeus mackenziensis</i>				4/5	3/3	3/5		
Belbodamaeidae								
<i>Veloppia pulchra</i>								6/9
<b>Eremaeidea</b>								
Eremaeidae								
<i>Eremaeus quadrilamellatus</i>		2/3						
<i>Eremaeus translamellatus</i>						1/1		1/1
<i>Eremaeus foveolatus</i>								
<b>Liacaroidea</b>								
Metrioppiidae								
<i>Ceratoppia bipilis</i>							1/2	
<i>Ceratoppia quadridentata</i>			4/4					
<i>Ceratoppia sexpilosa</i>		2/5						
<i>Ceratoppia</i> sp.	3/4			1/1	3/5	1/1		
<i>Metrioppia helvetica</i>	1/4	3/4	3/4	3/5	5/14			3/2
<b>Carabodoidea</b>								
Carabodidae								
<i>Carabodes labyrinthicus</i>		6/58	2/2	7/17		1/1		
Tetocephidae								

Explanation of figures: Number of cores (out of 10)/number of individuals





## Appendix 1. continued

Species	South Slope 43 spp.				Brooks Range 44 spp.			
	Site							
	1	2	3	4	6	7	9	a5
<i>Tectocephus velatus</i>	6/14	9/48	7/34	10/144	8/98	9/63	4/10	2/3
<b>Oppioidea</b>								
Oppiidae								
<i>Oppiella nova</i>	2/9	7/54	1/2	7/31	5/35	3/10		1/1
<i>Quadroppia quadricarinata</i>		1/2			8/57			10/141
<i>Oppia fissurata</i>	1/3		2/16				3/8	2/6
<i>Oppia translamellata</i>	7/42	9/42	9/207	8/34	8/89	9/305		4/6
Suctobelbidae								
<i>Suctobelbella acutidens</i>	3/3	2/7		1/3	8/34	6/31		
<i>Suctobelbella sarekensis</i>				1/1	6/49		1/1	
<i>Suctobelbella setoschavata</i>	1/2	2/9		2/6	1/4			
Thyrisomidae								
<i>Oribella</i> sv.					8/13	1/1		3/5
<b>Oribatuloidea</b>								
Orbatulidae								
<i>Liebstadia similis</i>	3/7	4/8		1/1	3/10	1/4		1/1
<i>Oribatula tibialis</i>	4/8	1/1				1/1		2/4
Haplozetidae								
<i>Peloribates canadensis</i>				2/16	1/2			1/1
<i>Peloribates pilosus</i>								
<b>Ceratozeteidea</b>								
Ceratozetidae								
<i>Ceratozetella</i> sp.					1/1			
<i>Ceratozetes</i> nr. <i>parvulus</i>					2/3			
<i>Ceratozetes</i> sp. 1	2/5	3/4						
<i>Ceratozetes</i> sp. 2				6/14	4/50			1/1
<i>Ceratozetes</i> sp. 3		1/3						
<i>Ceratozetes</i> sp. 4							1/2	2/2
<i>Ceratozetes</i> sp. 5							1/1	
<i>Ceratozetes</i> sp. 6								
<i>Melanozetes longisetosus</i>		1/1						
<i>Melanozetes meridianus</i>	2/3			3/5				1/1
<i>Fuscozetes sellnicki</i>				1/3	1/9	1/1		1/1
<i>Sphaerozetes arcticus</i>								
<i>Diapterobates</i> nr. <i>sitnikovae</i>								1/1
<i>Diapterobates variabilis</i>	1/1							
<i>Propelops groenlandica</i>					2/3			
<i>Iugoribates</i> sp.								5/8
<i>Trichoribates notatus</i>								
<i>Trichoribates polaris</i>								
Mycobatidae								
<i>Mycobates comitus</i>								
<i>Mycobates</i> nr. <i>punctatus</i>		3/9				3/3		
<i>Mycobates consimilis</i>			3/3	1/1				1/2
<i>Mycobates</i> sp. 2					6/13			2/3
<i>Mycobates</i> sp. 3		4/11	2/4					
<i>Mycobates</i> nr. <i>parmeliae</i>				1/1				

Archie

Foothills 31 spp.						Coastal Plain 30 spp.					no. of Sites	Biomass Est. ( $\mu$ g)
12	13	14	15	16		17	18	19	20	21		
2/2	1/1	6/35	1/1	6/10	4/13	3/4	5/8	5/6	1/1		18	1.2
1/1				4/8	1/1			1/1		1/1	12	1.0
	5/17	4/22	10/98					5/24	1/1		8	0.6
				3/20	2/4	8/22				1/1	8	0.9
	7/34	4/5	5/10	7/19	2/3		2/2	2/3		1/1	15	0.9
1/2				2/2							7	0.6
		2/9			1/1	1/1	2/2	1/1			8	0.6
											4	0.6
		6/16	6/15			2/7					6	6.2
	1/2										7	5.8
		2/4									5	7.5
											3	7.4
			1/1								1	9.8
											1	6.0
											1	2.0
											2	9.9
											3	13.5
											1	5.9
											2	11.3
											1	11.9
2/4					6/9		1/1				2	14.9
							2/2	3/4			5	20.1
				1/1						3/7	5	11.3
	5/11	2/2	1/1		1/2					6/18	5	4.8
				1/1						3/4	9	13.0
											1	12.5
				1/1							2	7.1
	1/1		6/11							1/1	4	5.1
											1	16.3
									1/1		1	14.1
										1/1	1	16.9
		6/16									2	9.7
										6/24	2	8.0
											3	8.4
											3	8.1
		2/12									2	11.7
											1	4.4

	South Slope 43 spp.				Brooks Range 44 spp.			
	Site							
Species	1	2	3	4	6	7	9	10
<b>Pelopoidea</b>								
Pelopidae								
<i>Eupelops septentrionalis</i>								
<b>Oribatelloidea</b>								
Oribatellidae								
<i>Oribatella arctica</i>								
Tegoribatidae								
<i>Scutozetes lanceolatus</i>								
<i>Tegoribates latirostris</i>					2/7			
Achipteriidae								
<i>Parachipteria nivalis</i>	1/4				4/8			10/71
<b>Galumnoidea</b>								
Parakalummidae								
<i>Neoribates aurantiacus</i>		2/5			2/2			
Total Number of Adult Oribatei spp./site	16	26	19	24	25	18	10	24
Brachychthoniid juv.	3/5	8/41	10/224	10/354	9/92	6/99	10/82	10/94
All other Oribatei juv.	9/31	10/147	10/98	10/394	10/180	8/153	10/60	10/103

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Arctic Foothills 31 spp.						Coastal Plain 30 spp.					no. of Sites	Biomass Est. ( $\mu$ g)
11	12	13	14	15	16	17	18	19	20	21		
			3/3					2/2			2	17.6
				1/1				1/1			2	7.4
				1/2		1/1					2	7.9
											1	8.5
		5/28	3/10	3/3	2/7		1/1	5/36	1/1		10	8.5
			1/1					1/1			4	13.4
9	13	19	16	19	15	10	10	12	7	10		
7/19	5/34	8/68	7/55	9/86	9/38	6/20	8/15	9/41	10/35	3/4	19	0.3
7/43	9/33	9/99	15/35	10/78	10/171	9/32	9/33	9/88	0/19	7/27	19	1.5

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## Appendix 2. Mesostigmata

Species	South Slope 12 spp.				Brooks Range 11 spp.			
	Site							
	1	2	3	4	6	7	9	10
<b>Sejoidea</b>								
Sejiidae								
<i>Sejus</i> sp.			1/1					
Microgynidae								
<i>Microgynium</i> sp.			1/1					
<b>Trachytoidea</b>								
Trachytidae								
<i>Trachytes</i> sp.			1/2		4/10	6/7	1/1	
Polyaspidae								
<i>Polyaspinus</i> sp.		1/1	1/1					
<b>Uropodoidea</b>								
Dinychidae								
<i>Dinychus micropunctatus</i>						5/12		
<i>Dinychus</i> nr. <i>micropunctatus</i>	5/7				5/10		1/1	5/11
<i>Dinychus</i> sp. 1	2/4	2/2		5/9				
<i>Dinychus</i> nr. <i>septentrionalis</i>								3/3
<b>Parasitoidea</b>								
Arctacaridae								
<i>Arctacarus rostratus</i>	1/2	6/14	3/3	6/7	2/2	2/3	1/2	5/7
<b>Rhodacaroidea</b>								
Ologamasidae								
<i>Gamasellus arcticus</i>	6/13	1/5	2/4	4/5	6/9	1/2		
<b>Dermanyssoidea</b>								
Laelapidae								
<i>Hypoaspis</i> sp.		1/1		1/1				
<b>Ascoidea</b>								
Ascidae								
<i>Cheiroseius</i> sp.								
<i>Zerconopsis</i> sp.							1/1	
<i>Arctoseius multidentatus</i>								
<i>Arctoseius ornatus</i>							2/2	
<i>Iphidozercon</i> sp.								
Zerconidae								
<i>Parazercon</i> sp.		1/2					1/2	
<i>Zercon</i> spp.	2/2	1/1	3/13	1/1	3/3	1/4	1/1	5/10
<i>Zerconid</i> (gen. nov.)		2/4	1/1	1/1	2/2	2/3		
<b>Phytoseioidea</b>								
Phytoseiidae								
<i>Typhlodromus</i> sp.								

\* Order of families as in BEHAN (1978)

Arctic Foothills 10 spp.						Coastal Plain 14 spp.					no. of Sites	Biomass Est. ( $\mu\text{g}$ )
11	12	13	14	15	16	17	18	19	20	21		
											1	41.9
				1/1							2	1.9
											4	8.6
											2	7.8
	1/2								6/11	2/6	4	3.9
	3/4	3/12	5/8	1/1				1/1			9	4.3
			6/15	1/1							5	7.3
			1/1	1/1	1/1	2/2	2/2	3/5			7	7.5
	6/17	2/3	4/4	1/1	1/1		1/1	2/2			15	32.6
	2/3	5/5		2/3				1/1		3/6	11	7.9
								1/1			3	6.7
			1/1								1	4.5
											1	19.6
								1/3			1	8.8
2/2								2/2	4/8		4	5.5
								2/2	1/1		2	1.2
											2	1.4
4/4	7/14			3/3	1/1				1/2		13	4.1
				1/3	1/1	1/1					8	1.6
							1/1				1	3.5

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#### *Synopsis: Original scientific paper*

THOMAS, R. H., & S. F. MACLEAN, Jr., 1988. Community structure in soil Acari along a latitudinal transect of Tundra sites in Northern Alaska. *Pedobiologia* **31**, 113—138.

Soil microarthropods are an important component of the detritus-based trophic system. Parameters of community structure were examined for the mite faunas on a series of plots in a tundra areas along a 600 km north-south transect following the trans-Alaska oil pipeline transportation corridor. Hypotheses derived from the Soviet zonal concept of organismic distribution were tested. No relationship was apparent between faunal abundance and either soil organic matter content or plant biomass. Sampling problems in making comparable estimates of species richness are discussed. Heterogeneity of spatial distribution of oribatid species increases with latitude and decreasing species richness, indicating restriction to favorable microsites with increasingly severe conditions. Burning of tundra vegetation and oil spills reduce both density and species richness; recovery appears to be slow. These results refute the hypothesis of zonal regularity in fine-scale studies of faunal organization. Population level approaches are recommended for future studies.

**Key words:** Alaska, tundra, latitudinal transect, soil, Acari, community, structure, distribution.